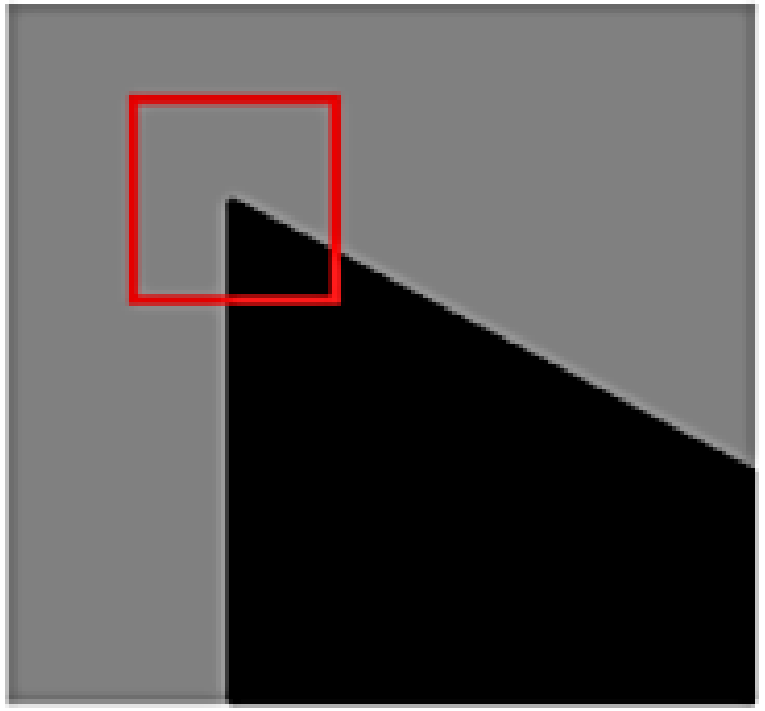
Computer Vision

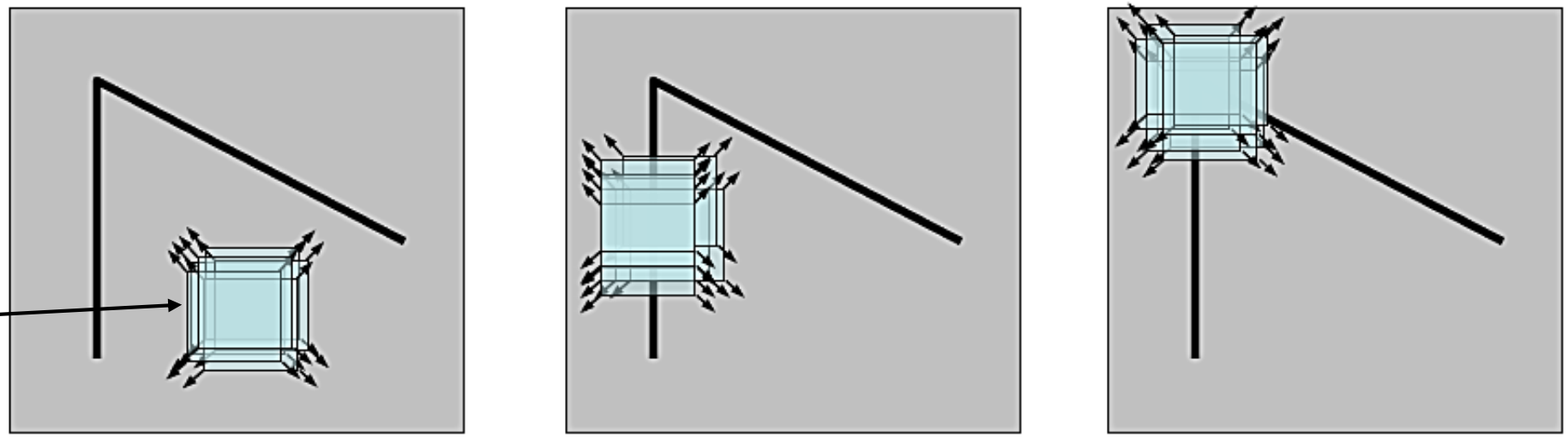
Section 2

Corner

- A corner is a point where **two or more edges meet**, making it a highly distinctive feature.
- Corners are considered **stable and unique** features because they remain identifiable even under transformations such as scaling, rotation, and slight illumination changes.
- Corners are useful features for various tasks such as object recognition, image matching, motion tracking, and 3D reconstruction.



Corner Detector (General Definition)



"flat" region:
no change in
all directions

"edge":
no change along
the edge direction

"corner":
significant change
in all directions

Harris Corner Detection

Mathematical Formulation

1. **Compute Image Gradients**
   - Compute the first-order derivatives using Sobel filters.
2. **Compute the Structure Tensor (Second-Moment Matrix) H**
3. **Compute the Corner Response Function C**
4. **Classify the Feature Points**
   - **Corner: if C** is **large and positive**
   - **Edge: if C** is **negative**
   - **Flat Region:** if C is **close to zero**.

Harris Corner Detection

Compute Image Gradients

Input Image

0	0	1	4	9
1	0	5	7	11
1	4	9	12	16
3	8	11	14	16
8	10	15	16	20

5*5

Differentiation Kernels

−1	0	1

d/dx

−1
0
1

d/dy

Harris Corner Detection

Compute Image Gradients

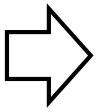
Input Image

0	0	1	4	9
1	0	5	7	11
1	4	9	12	16
3	8	11	14	16
8	10	15	16	20

5*5

d/dx

−1	0	1



IX

x	x	x	x	x
x	4	7	6	x
x	8	8	7	x
x	8	6	5	x
x	x	x	x	x

5*5

Harris Corner Detection

Compute Image Gradients

Input Image

0	0	1	4	9
1	0	5	7	11
1	4	9	12	16
3	8	11	14	16
8	10	15	16	20

5*5

d/dy

−1
0
1

IY

x	x	x	x	x
x	4	8	8	x
x	8	6	7	x
x	6	6	4	x
x	x	x	x	x

5*5

Harris Corner Detection

Compute the Structure Tensor H

IX

x	x	x	x	x
x	4	7	6	x
x	8	8	7	x
x	8	6	5	x
x	x	x	x	x

5*5

IY

x	x	x	x	x
x	4	8	8	x
x	8	6	7	x
x	6	6	4	x
x	x	x	x	x

5*5

H

403	385
385	381

$$\sum IX^2 = 4^2 + 7^2 + 6^2 + 8^2 + 8^2 + 7^2 + 8^2 + 6^2 + 5^2 = 403$$

$$\sum IY^2 = 4^2 + 8^2 + 8^2 + 8^2 + 6^2 + 7^2 + 6^2 + 6^2 + 4^2 = 381$$

$$\sum IX * IY = 4*4+7*8+6*8+8*8+8*6+7*7+8*6+6*6+5*4 = 385$$

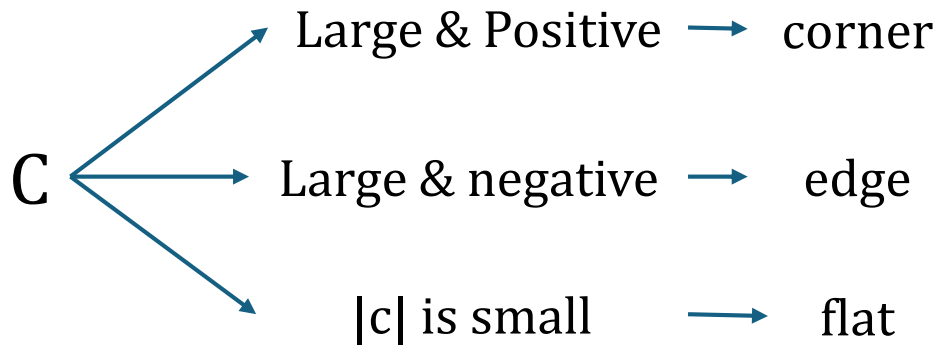
Harris Corner Detection

Compute the Harris Response Function C

H

403	385
385	381

$$C = \det(H) - k\,\mathrm{trace}(H)^2$$



$$C = 5318 - 0.04 * (784)^2 = -19268.24$$

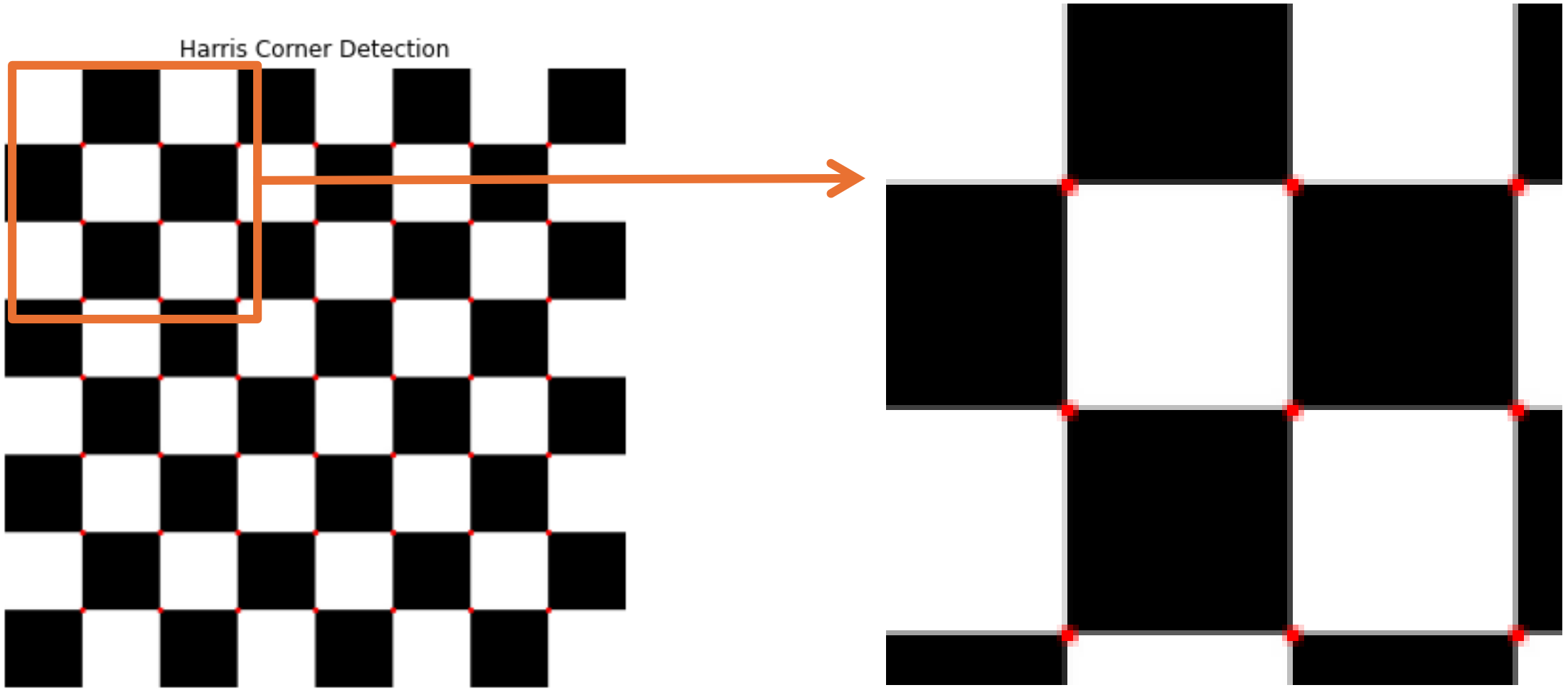
Edge

Harris Corner Detection

Steps to Estimate Corners Using the Harris Detector

- Convert the image to **grayscale**.
- Compute the **image gradients**.
- Construct the **structure tensor**.
- Compute the **Harris response function C**.
- **Threshold** the response to detect strong corners.

Harris Corner Detection



Thanks